

CLAIMS

What is claimed is:

1. In an implantable medical device for implant within a patient, a method comprising:
 - receiving electrical cardiac signals;
 - identifying segments of the cardiac signals subsequent to ventricular repolarization; and
 - detecting cardiac ischemia based on an examination of the segments subsequent to ventricular repolarization.
2. The method of claim 1 wherein detecting the cardiac ischemia is performed to detect cardiac ischemia so as to predict a subsequent acute myocardial infarction (AMI).
3. The method of claim 1 wherein detecting the a ischemia based on an examination of segments of the cardiac signals following the ventricular repolarization comprises:
 - detecting a sharp falling edge within electrical cardiac signals within the segments following ventricular repolarization.
4. The method of claim 3 wherein detecting the sharp falling edge comprises:
 - filtering the cardiac signals to yield a high-pass filtered signal;
 - deriving an energy value representative of a total amount of energy in the filtered signal within each segment following each ventricular repolarization;
 - 25 deriving a running average of the energy value;
 - inputting first and second threshold values; and

detecting the sharp falling edge based on a comparison of the energy value, the running average, and the first and second thresholds.

5. The method of claim 4 wherein filtering the cardiac signals comprises:

routing the cardiac signals through a high-pass filter having a cutoff frequency in the range of 0.1 to 5.0 Hz.

6. The method of claim 4 wherein filtering the cardiac signals comprises:

10 routing the cardiac signals through a high-pass filter having a cutoff frequency of at least 1 Hz.

7. The method of claim 4 wherein deriving the energy value comprises calculating:

$$E_{PostT} = \sum_{k=T_{start}}^{T_{end}} s(k)$$

15 for each segment of the cardiac signals, wherein $s(k)$ is a digitized version of the filtered cardiac signal, T_{start} and T_{end} are start and end points, respectively, of the segment, and k represents individual samples of the digitized signal.

20 8. The method of claim 7 further comprising initially calculating T_{start} and T_{end} by:

identifying a pair of consecutive ventricular depolarizations (S1 and S2) within the cardiac signals;

25 determining a time interval (S_to_S_Interval) between S1 and S2; setting T_{start} equal to $S1 + S_to_S_Interval / 4$; and setting T_{end} equal to $S2 - S_to_S_Interval / 4$.

9. The method of claim 7 wherein deriving the running average comprises calculating:

$$E_{PostT_Ave}(i) = \alpha \cdot E_{PostT_Ave}(i-1) + (1-\alpha) \cdot E_{PostT}$$

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at time increment "i" where α is a predetermined value and wherein $E_{PostT_Ave}(0)$ is set to a default value.

10. The method of claim 9 wherein α is equal to 15/16.

11. The method of claim 4 wherein detecting the sharp falling edge based on a comparison of the energy value, the running average, and the first and second thresholds comprises:

15 determining whether either an absolute value of the energy integral minus the running average exceeds the first threshold or an absolute value of just the running average exceeds the second threshold for a predetermined number of heart beats; and

if so, generating a signal indicative of the onset of ischemia.

12. The method of claim 11 further comprising detecting end of the episode of ischemia by:

20 determining whether both absolute value of the energy integral minus the running average falls below the first threshold and the absolute value of just the running average falls below the second threshold for a predetermined number of heart beats; and

25 if so, generating a signal indicative of the end of the episode of ischemia.

13. The method of claim 1 further comprising:
generating a warning signal indicative of the ischemia.

14. The method of claim 13 wherein generating a warning
signal indicative of the ischemia comprises:

5 applying a perceptible electrical notification signal to subcutaneous
tissue.

15. The method of claim 13 wherein generating a warning
signal indicative of the ischemia comprises:

transmitting a notification signal to a warning device external to the
10 patient.

16. In an implantable medical device for implant within a
patient, a method comprising:

receiving electrical cardiac signals;
filtering the cardiac signals to yield a band-pass filtered signal;
15 deriving energy values representative of a total amount of energy
within portions of the filtered signals subsequent to
ventricular repolarizations; and
detecting cardiac ischemia based on a comparison the energy
values against threshold values.

20 17. In an implantable medical device for implant within a
patient, a method comprising:
detecting cardiac ischemia based on an examination of portions of
electrical cardiac signals following ventricular
repolarizations; and
25 if cardiac ischemia is detected, generating a perceptible warning
signal to alert the patient.

18. In an implantable medical device for implant within a patient, a system comprising:

5 a sensing circuit operative to receive electrical cardiac signals and to identify segments of the cardiac signals subsequent to ventricular repolarization; and

 a cardiac ischemia detector operative to detect cardiac ischemia based on an examination of the segments of the cardiac signals following ventricular repolarization.

19. In an implantable medical device for implant within a patient, a method comprising:

10 a sensing system operative to receive electrical cardiac signals and to identify segments of the cardiac signals subsequent to ventricular repolarization;

 a bandpass filter operative to filter the segments subsequent the ventricular repolarization to yield a band-pass filtered signal;

15 a filtered signal integration unit operative to determine energy values representative of a total amount of energy within portions of the filtered signals subsequent to ventricular repolarizations; and

 a threshold comparison unit operative to compare the energy values against threshold values indicative of cardiac ischemia; and

20 a cardiac ischemia warning system operative to output a signal indicative of the ischemia.

20. In an implantable medical device for implant within a patient, a system comprising:

means for receiving electrical cardiac signals;

means for filtering the cardiac signals to yield a band-pass filtered signal;

means for deriving energy values representative of a total amount of energy within portions of the band-pass filtered signals subsequent to ventricular repolarizations;

means for detecting cardiac ischemia based on a comparison the energy values against threshold values; and

means for generating a warning signal indicative of cardiac ischemia.